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An Antidote to the Resource Curse: The Blessing of Renewable Energy

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ABSTRACT: This paper empirically examines the validity of the resource curse in Europe and it is the first time renewable energy is inserted in this research context. The study uses panel data with a variety of explanatory variable proxies for investment, openness, rule of law, resource endowments and human capital. It employs a single equation fixed effects model with heteroskedasticity robust covariance and a simultaneous two equation model where renewable energy enters the structural equation as an endogenous variable. The resource curse is confirmed only for crude oil and resource productivity in the single equation model while renewable energy has a positive relationship to growth. In the simultaneous two equation model, countries with high oil production and emissions also have a higher production of renewable energies.

Keywords: Natural resource curse; economic growth, renewable energy; Europe; fixed effects model
JEL Classifications; O52; P28; P48; P52; Q20

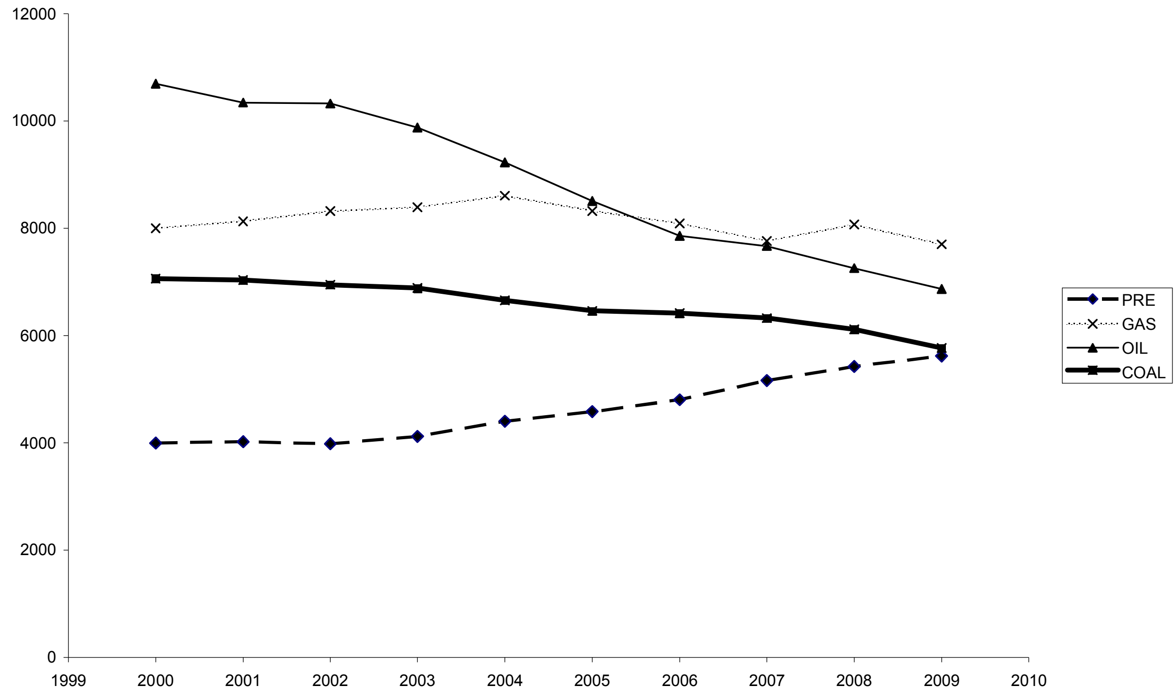
1. Introduction

Contrary to basic common sense, empirical studies consistently find that resource curse exploitation and dependence is accompanied with poor economic growth across countries or even entities of a more disaggregated level (James and Aadland, 2011). With the exception of few countries such as Great Britain and Germany that deployed resources in a profitable way to themselves (with their ore and coal resources), by investing them to increase their prosperity, there are many other examples which define the paradox. For instance, Japan or Switzerland with very limited resources, have nevertheless achieved remarkable growth rates while vice-versa, countries with rich resource endowments have experienced meager growth rates and entered the vicious circle of poverty and underdevelopment, giving rise to a number of structural and agency based political economy explanations. Decisions of political elites together with rent-seeking behaviors affect resource exploitation and are highly probable to inhibit renewable energy development through patronage activities and 'white elephant' investments. A conflict might arise between the existent actors in non-renewable resources and the actors of renewable ones. If demand for non-renewable resources slows down, the existent actors will seek compensation for their decline of dividends and try to maintain their status-quo. However, despite the competitive roles of fossil fuel and renewable energy, renewable energy is both diffuse and highly diversified, so that rent-seeking behavior is more difficult to achieve.

Renewable energy sources are currently unevenly and insufficiently exploited in the European Union (EU). Although many of them are abundantly available, and their real economic potential is considerable, they make only a small contribution of about 7.8-8% to the EU overall gross inland energy consumption. The EU's dependence on energy imports is already 53.1% and is expected to rise reaching 70% by 2020. This applies particularly for oil and gas.

Figure 1 depicts the intertemporal production of renewable energy, crude oil, gas, coal and lignite in Europe from 2000- 2009. The increasing production of renewable energy is accompanied by a decreasing production of crude oil, coal and lignite and a somewhat stable production of gas. The demand for coal and gas is driven by the fact that they remain the lowest cost technologies for electricity generation in most parts of the world (Borenstein, 2012).

Figure 1. Mean Renewable energy and fossil fuel energy production across Europe in 2000-2009.



The Kyoto Protocol to the United Nations Framework Convention on Climate Change was a cornerstone in the promotion of renewable energy sources. In spite of the various European directives for the promotion of RES being the 2001/77/EC on electricity production from renewable energies (European Commission, 2001), the 2002/91/EC on energy performance of buildings (European Commission, 2002), the 2003/30/EC on the promotion of biofuels and other bioliquids (European Commission, 2003) and the 2009/28/EC on the promotion of the use of energy from RES (European Commission, 2009), which demanded that renewable energies in final gross energy consumption in Europe doubled from 6 to 12% and achieving 22% electricity production from RES by 2010, also a reduction in primary energy use by 20% and a reduction of greenhouse gases by 20% below the 1990 levels, nevertheless there is evidence for the neutrality hypothesis between renewable energy and growth (Menegaki, 2011;2012).

This paper consists of five parts. After the introduction, it also comprises a literature review, basic theory of the fixed effects model, data and results followed by a conclusion section.

2. Literature Review

The literature on the resource curse seeks explanation to the puzzling phenomenon of countries endowed with natural resources which at the same time become outperformed by countries with less resource endowments despite the natural capital they are supposed to be accumulating. Various explanations are purported about the resource curse hypothesis. One of the them is the Dutch effect according to which natural resource abundance leads to an appreciation of the real wage rate and real exchange rate which in turn raises the cost of exports and a country becomes less competitive in the traded economy, the agricultural and manufacturing sectors, particularly when these sectors are characterized by economies of scale, learning and productivity changes (Sachs and Warner, 1995). The revenue volatility from rents and a long-term declining trend in the terms of trade for resource exporters should not be overseen (Auty, 2001).

Another explanation to the resource curse stems from decentralized political economy models. When a country relies on its natural resources, this causes the reallocation of human resources, labor and capital from high-technology and high-skilled manufacturing sector to the low-technology and low-skilled natural resource sector. Natural resources lead to engaging in non-productive activities and the state to under-provide public goods because rents are not invested in social wealth.

Besides the education level shortages thus incurred, institutions in a country also matter because they affect and shape the political or economic model of governance pursued in one country

(Andersen and Aslaksen, 2008). Particularly the latter elaborates in that the resource curse is more probable to realize in presidential democratic countries rather than parliamentary democratic countries, because the former have a tendency to favor powerful minorities. Robinson et al. (2006) state that resource dependent economies are characterized by dysfunctional state behavior, large public sectors, a poor rule of law and unsustainable budgetary policies provoked by favoritism and not the general public interest, while Williams (2011) highlights the negative role of political elites and governments' lack of transparency on growth.

Interestingly, resource rich countries run the risk of violent conflicts and poor democracy accountability. According to Melhum et al. (2006) this difference in the growth performance of rich-resource countries is due to the rent distribution through institutional arrangements, corruption included, which reflects directly to the inability of governments to manage large resource revenues in a sustainable way, i.e. their inability to transform rents into net saving, all this termed as 'Nigerian disease' by Williams (2011). Public employment (patronage) can be a politically appealing way to distribute rents, as documented in centralized political economy models (Alesina et al, 1998).

There is a vast literature on the topic of resource curse dealing with its various facets. Some studies are concerned with the definition of the phenomenon and whether it holds throughout the world, other experiment with different econometric methods or definitions of variables and transmission channels as termed by Papyrakis and Gerlagh (2004). Existent is also literature supporting that rich countries can circumvent the resource curse problem (Auty, 2001). Departure being that the resource curse might not be a deterministic phenomenon but rather a policy oriented one, resource rich countries might reap both costs and benefits as a result of their natural wealth (Stijns, 2006).These countries can achieve that because usually they have well functioning institutions, that deal effectively with distributional conflicts (Mikesell, 1997) and are flexible in handling the general equilibrium effects that ensue at the different stages of the production circle in an economy (Leamer et al., 1999). Moreover the type of resource present in each country can determine the presence and the degree to which a country is inflicted by the curse. Williams (2011) thus distinguishes between point resources (fuels, ores, metals) and diffuse resources (mainly agriculture). The latter are less prone to the curse. Boschini et al (2007) and Mehlum et al (2006) further refine their results by noticing that the effect of institutions is larger in the case of minerals rather than on the rest of the resources. Therefore the usage of certain variables needs caution and cross-validation for result robustness.

3. The Fixed Effects Model

An important modelling issue in panel data sets is the heterogeneity of the countries encompassed in the data set. The effects models are generally preferred for their simplicity in handling and normalizing heterogeneity in the error term. While in fixed models the interest lays in the individual means across the levels of the fixed factor, in random effects models the interest lays in the variance of means across the levels of a random factor. By assumption, the random effects model is homoskedastic, since all disturbances have variance equalled to σ^2. In random effects models there is an inherent individual effect, but this effect is regarded as random. In other words, heterogeneity is assumed to be uncorrelated with the included variables. In one way fixed effects models, a separate fixed constant term is typically introduced for each country, which might be very impractical due to the large number of regressors, particularly in small samples. The one way fixed effects model is provided in Equation 1

$$y_{it} = a_1 d_{1it} + a_2 d_{2it} + \ldots + \beta' x_{it} + \varepsilon_{it}$$
$$y_{it} = a_i + \beta' x_{it} + \varepsilon_{it} \qquad (1)$$

with $E[\varepsilon_{it} \mid X_i] = 0$, $Var[\varepsilon_{it} \mid X_i] = \sigma^2$ and

$Cov[\varepsilon_{it}, \varepsilon_{js} \mid X_i, X_j] = 0$ for all i,j, $Cov[a_i, x_{ij}] \neq 0$

The two way fixed effects model is provided in Equation 2

$$y_{it} = a_0 + a_i + \gamma_t + \beta' x_{it} + \varepsilon_{it} \qquad (2)$$

Besides the overall constant, the two-way fixed model encompasses group effect for each group and a time effect for each period. There are two standard devices (Greene, 2007) for distinguishing whether the fixed effects or the random effeects specification is more appropriate. The first is the Breusch- Pagan (1980) LM statistic which tests the null hypothesis that there are no group effects in the random effects model. This test is based on OLS residuals. For $H_0 : \sigma_u^2 = 0$, $H_1 : \sigma_u^2 \neq 0$, the test statistic is provided in Equation 3 (Greene, 2003):

$$LM = \frac{nB}{2(B-1)}\left[\frac{\sum_{i=1}^{n}\left[\sum_{t=1}^{B} e_{it}\right]^2}{\sum_{i=1}^{n}\sum_{t=1}^{B} e_{it}^2} - 1\right]^2 = \frac{nB}{2(B-1)}\left[\frac{\sum_{i=1}^{n}\left(B\bar{e}_i\right)^2}{\sum_{i=1}^{n}\sum_{t=1}^{B} e_{it}^2} - 1\right]^2 \quad (3)$$

where $\bar{e}$ is the means of the least squares residuals, B =observations in group *i*

The second is Hausmann chi square statistic result (1978) testing whether the Generalized Least Square (GLS) estimator is an appropriate alternative to the LSDV (Least Square Dummy Variable) estimator (Greene, 2003, Judge et al., 1985). Hausmann's test is used to test the orthgonality of the random effects and the regressors. The test assumes that under the hypothesis of no correlation, both OLS in the LSDV model and GLS are consistent, but OLS is inefficient. Hausmann's result is that the covariance of an efficient estimator with its difference from an inefficient estimator is zero. Therefore, a high Breusch- Pagan LM statistic, with 1df and probability value less than 5%, and the high Hausmann's chi square statistic favoured the fixed effects model against the random effects (Greene, 2003).

Greene (2007) conditions the fixed effects out of the density and estimates the parameters of interest after taking advantage of the Frisch-Waugh theorem for partitioned least squares regression. A separate constant term is estimated for each group, as opposed to an overall constant and constants for N-1 of the groups. The individual constant terms are then computed as the group specific residuals in Equation 4

$$a_i = \sum_{t=1}^{T_i}\left(y_{it} - \bar{y}_i\right) - \left(x_{it} - \bar{x}_i\right)' b \quad (4)$$

When there is autocorrelation, the model is first partial differenced using the value of rho. Limdep (Ver. 9.0) saves the fixed effects computed for this models is a matrix named alphafe which is available to the interested readers after request. The two-way fixed effects model is estimated by creating time specific dummy variables. We will not elaborate further on it because we are not employing it since time was not significant and the additional r-squared produced from the time effects was negligible.

Robust estimation of the fixed OLS covariance matrix

We use a counterpart to the White estimator for unspecified heteroskedasticity. This is shown in Equation 5

$$EstVar[b] = \left(X^{*\prime} X^{*}\right)^{-1} \times \sum_{i=1}^{n} \frac{e_i^2}{\left(1 - x'\left(X^{*\prime} X^{*}\right)^{-1} x^{*}_{ii}\right)^2} x_i^{*} x_i^{'*} \times \left(X^{*\prime} X^{*}\right)^{-1} \quad (5)$$

Two stage least squares

We will estimate a model with an endogenous variable in the form of a simultaneous equations model. The set up corresponds to the following formulation

$$y_{1i} = a_{1i} + \gamma_2 y_{2i} + \gamma_3 y_{3i} + \ldots + \beta' x_{1i} + \varepsilon_{1i} \quad (6)$$

with the remaining structural equations

$y_{ji} = f_j\left(y_{1i}, \ldots X, \varepsilon_{ji}\right)$, with j being an enumeration for the equations. We regress y_j on all the x*s* and compute the predicted values from the first regression. The second equation is estimated with the inclusion of the above predicted values as an instrumental variable. The estimator then adjusts the computation of variance estimators for the presence of the predicted value. This treatment is described as a two stage least squares.

4. Data and Results

Annual data ranging from 2000 to 2009 for 31 European countries (appendix A1) were obtained from Eurostat. Summary statistics are provided for each of the variables in Table 1. The time span and the included countries were contingent upon data availability. The variables were chosen as the most appropriate proxies for the following parameters: growth, investment, terms of trade and representative political economy variables such as openness, rule of law, renewable energy and resource endowments. The choice for the primary production of oil, gas, coal and lignite instead of the subsoil assets (as indicated by World Bank), was led by the fact that the measure of subsoil assets is proportional to current rents and thus also endogenous (van der Ploeg and Poelhekke, 2010). Therefore to correct for this, we used primary production of the various resources which are "proven reserves". Furthermore, openness was important to include because protectionist barriers for import-substitution affect growth. Last, transparency and government accountability have been introduced through the variables of E-governance and European Union transposition. Our variable for growth was replaced by various others such as real GDP per capita, growth rates of real GDP per capita and net national income, but the purchasing power parities variable had the best fit and yielded better results.

Table 1. Definition of variables and descriptive statistics

Variable	Definition	Mean	St.dev.	Min.	Max.
GDP and Income variables					
PPS	GDP per capita in Purchasing Power Parities	101.441	77.606	26	1223
INV	Total investment (% of GDP)	19.759	12.361	1	190.26
Resource variables					
OIL	Primary production of crude oil (1000 toe)	9120.44	29985.8	0	166070
RPR	Resource productivity (euro per kg)	1.168	1.137	0.12	14
PRE	Primary production of renewable energy (1000 toe)	4774.91	5304.46	38	27968
GAS	Primary production of natural gas (1000 toe)	8982.55	21195.7	0	97554
COAL	Primary production of coal and lignite (1000 toe)	6779.53	15315	0	71026
DEP	Energy dependence (% of net imports in gross inland consumption)	67.938	123.416	-703.80	802.28
Education variables					
RD	Research and development expenditure (% of GDP)	1.458	0.936	0.25	4.13
TERT	Tertiary education participation	647.58	783.85	2.40	2924.3
EED	Expenditure on education (% of GDP)	5.227	1.245	2.59	8.72
KNO	Employment in knowledge-intensive activities (% of total employment)	37.992	9.333	16.80	60
EAR	Early leavers from education and training (percentage of the population aged 18-24 with at most lower secondary education)	16.125	10.880	3.70	54.4
Trade variables					
SWE	Shares of world exports (5 year % change)	9.042	21.961	-24.20	77.70
IGO	Market integration in goods (Average value of imports and exports of goods divided by GDP in %)	36.135	16.153	1	77.70
IGS	Market integration in services (Average value of imports and exports of services divided by GDP in %)	13.775	14.827	1	99.89
Various variables					
EGO	E-government availability (supply side)	43.909	30.105	0	100
TRA	Transposition of EU law (%)	66.450	45.507	1	99.90
GRE	Greenhouse gas emissions (CO_2 equivalent) in thousands of tonnes	89.76	96.67	8.41	696.96

Note: Variable explanations and sources are reported in Appendix A2.

Four estimation specifications have been deployed (Table 2). Although the discussion concentrates on results from the heteroskedasticity robust covariance fixed effects model (HFEM), we also list the results from OLS, FEM and REM for reasons of comparison. Since the Breusch-Pagan and Hausman test statistics support the fixed effects model specification versus the random effects model, we further elaborate the simple fixed effects results (FEM) into a HFEM for unspecified heteroskedasticity. Various configurations of heterogeneity were also tested but were not significant. Given that all variables are significant in HFEM, we will only comment on the sign of the regressors.

Table 2. The estimated results for panel data single equation

Variable	Ordinary least squares-OLS	Fixed effects models-FEM	Heteroskedasticity robust covariance fixed effects model-HFEM	Random effects model-REM
Constant	25.302 (0.047)	***	***	70.223 (0<0.001)*
Total Investment	0.303 (0.002)*	0.018 (0.464)	0.018 (0<0.001)*	0.030 (0.235)
Primary production of crude oil	0.0002 (0.722)	-0.0001 (0<0.001)*	-0.0001 (0<0.001)*	-0.0001 (0.037)*
Resource productivity	-0.106 (0.920)	-0.723 (0.266)	-0.723 (0<0.001)*	-0.440 (0.171)
Primary production of renewable energy	0.001 (0<0.001)*	0.0001 (0.241)	0.0002 (0<0.001)*	0.00002 (0.888)
Primary production of natural gas	0.0003 (<0.001)*	0.0003 (0<0.001)*	0.0004 (0<0.001)*	0.0004 (0<0.001)*
Primary production of coal and lignite	0.0007 (0.453)	0.00006 (0.889)	0.00003 (0<0.001)*	-0.0003 (0.009)*
Energy dependence	0.022 (0.008)*	-0.003 (0.183)	-0.003 (0<0.001)*	-0.004 (0.099)**
Research & Development expenditure	3.626 (0.134)	-5.426 (0<0.001)*	-5.425 (0<0.001)*	0.874 (0.633)
Tertiary education participation	-0.010 (0.001)*	0.003 (0.163)	0.003 (0<0.001)*	0.001 (0.627)
Expenditure on education	-6.870 (<0.001)*	-4.425 (0<0.001)*	-4.424 (0<0.001)*	-2.564 (0.003)*
Employment in knowledge-intensive activities	2.452 (<0.001)*	0.208 (0.225)	0.208 (0<0.001)*	0.818 (0<0.001)*
Early leavers from education	-0.027 (0.834)	-0.242 (0.099)**	-2.242 (0<0.001)*	-2.974 (0.238)
Share of world exports	-0.213 (<0.001)*	-0.018 (0.393)	-0.018 (0<0.001)*	0.005 (0.809)
Market integration in goods	-0.588 (<0.001)*	-0.248 (0<0.001)*	-0.248 (0<0.001)*	-0.238 (0<0.001)*
Market integration in services	1.415 (<0.001)*	0.525 (0<0.001)*	0.525 (0<0.001)*	0.835 (0<0.001)*
E-government availability	-0.032 (0.462)	0.014 (0.388)	0.014 (0<0.001)*	-0.020 (0.195)
Transposition of EU law	0.120 (<0.001)*	0.088 (0<0.001)*	0.088 (0<0.001)	0.090 (0<0.001)*
Greenhouse gas emissions	-0.000 (0.627)	0.000 (0.015)*	0.000 (0<0.001)	0.000 (0.061)**
R-squared	0.902	0.993	0.993	---
Adjusted R-squared	0.895	0.992	0.992	---
F	138.82	807.68	807.68	---
Hausman test	---	---	---	164.02
Breusch Pagan statistic	---	---	---	495.56
Var(u)	---	---	---	0.000
Corr[v(i,t),v(i,s)]	---	---	---	0.925

Notes: *indicates 5% significance, ** indicates 10% significance, *** the constant is not reported because of the alphafe (see section 2).

Overall, growth (in PPS terms) is positively affected by total investment, primary production of renewable energy, gas, coal and lignite production, tertiary education participation, the employment of knowledge-intensive activities, the market integration of services, the e-government availability, the transposition of European Union law and the greenhouse gas emissions.

A negative relationship there is between growth and primary production of crude oil, resource productivity, energy dependence, expenditure on education, early leavers from education, shares of world exports and market integration of goods. Therefore, the resource curse hypothesis is confirmed only for one type of resource, the crude oil which has a negative sign. Moreover, resource productivity has an inverse relationship with growth which in a way, can be regarded as a weak confirmation of the resource curse.

The positive relationship between growth and renewable energy and the non-confirmation of the resource curse has a political economy explanation: Resources that need considerable technological development for their exploitation (this is also the case for renewable energy) may spur technological advances and through their valuable education spillovers, eventually lead to growth, minimizing the typical negative side effects from resource rents (Gylfasson, 2008; Kolstad and Wiig, 2009). Of course we cannot escape the explanation that rich countries may be immune to the resource curse if certain conditions are fulfilled (Auty, 2001).

Interestingly, in our application, R&D expenditure and education expenditure do not increase growth. This finding begs the question of how efficient this expenditure is or put in different words, whether it produces true and competitive knowledge or it is just spending for useless reproduction. On top of that, the knowledge-intensive labor seems to positively affect growth. Of course, the two education proxies (education expenditure and knowledge intensive labor) are not equivalent in meaning. For example a state might be spending on education, but if the education system of a country is not connected with new high technologies that add to specialization, then knowledge intensive labor will not be implemented. Therefore, expenditure on education, does not tell how efficient education is, or what its connection to the job-sector is. Last, the variable 'early leavers from education' has a negative sign and does not affect growth.

Economy openness is another factor that is typically studied in relevant literature for its contribution to growth. Although with a small coefficient, the share of world's exports has a negative sign, showing a negative effect on growth. Even if this can constitute some evidence for the "dutch disease phenomenon", we nevertheless report this finding without further research which would be necessary to characterize the phenomenon. The same applies with the market integration of goods, but not of services, where a positive relationship is observed with growth.

The positive significance of European Law transposition variable means that growth is law ordered. The institutional quality proxy variable was not significant which might be due to the fact that further initiative and incentives are needed to generate a sustainable institutions level. Of course not much can be said about the possible contribution of institutions into growth in Europe, because we have included only one relevant variable in our equation (more variables could not be used because, due to serious data gaps in some countries, which would have created an extremely unbalanced panel data set).

A two effects model was not preferred, because of the short time span of the data which is thought to be governed by a single development mechanism. Therefore, we examined no structural breaks. Also, a comparison of the r-squared statistic among a regression with group effects only, X variables only and X variables with time effects (0.985, 0.9935 and 0.9938) resulted in that the contribution of time provides negligible additional explanation in the variability of the dependent variable.

To account for endogeneity of the variable *production of renewable energy*, we address the problem with instrumental variables and by specifying a system of simultaneous equations with heteroskedasticity robust covariance matrix (Table 3). Regarding renewable energy as endogenous, means that we believe that it is determined as a function of various causal factors, such as the production of other types of fossil fuel energy, education variables as well as the degree of rule of law in a country.

Table 3. Two-stage least squares simultaneous equations

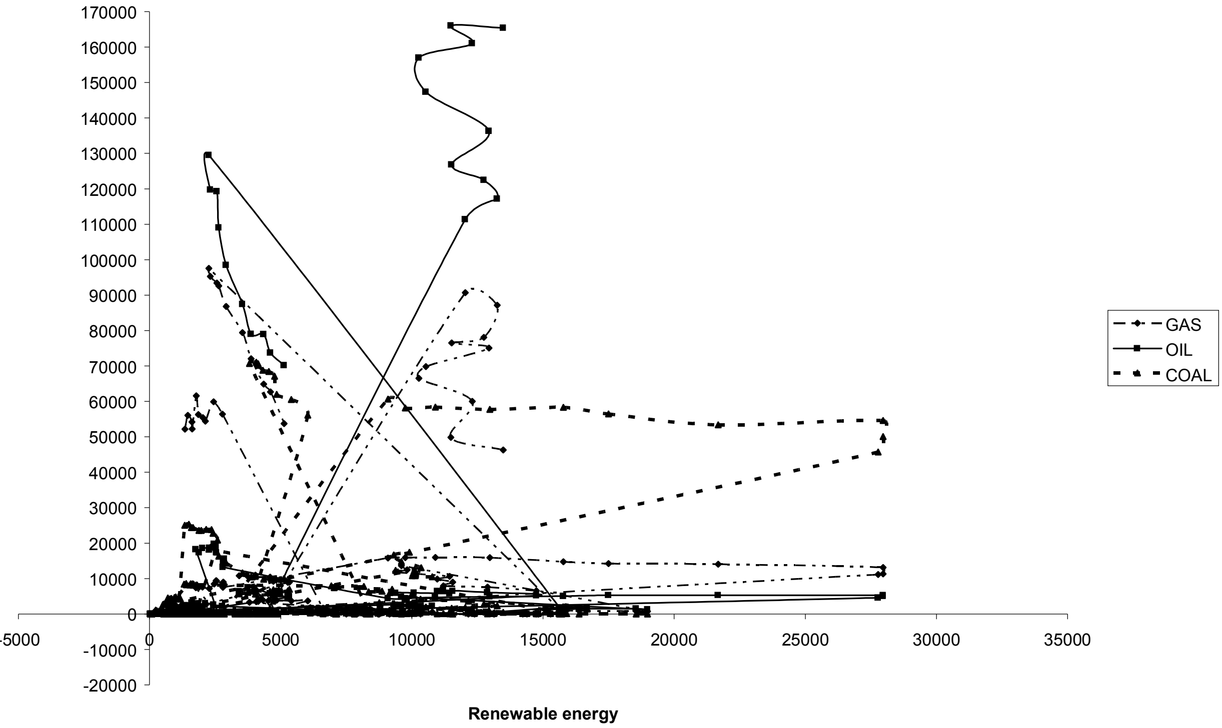
Variables and statistics	Coefficient (p-value)	
	Equation 1- dependent variable: Purchasing Power Parities	Equation 2 - dependent variable: Renewable energy production
Constant	30.802 (0.018)*	-1195.932 (0.407)
Total Investment	0.321 (0.590)	-19.007 (0.187)
Primary production of crude oil	0.0001 (0.705)	0.048 (0.000)*
Resource productivity	-0.157(0.173)	1.395 (0.476)
Primary production of renewable energy	0.002 (0.43)	
Primary production of natural gas	0.0001 (<0.001)*	-0.094 (0.000)*
Primary production of coal and lignite	-0.000 (0.789)	-0.045 (0.003)*
Energy dependence	0.019 (0.523)	5.604 (0.000)*
Research & Development expenditure	8.920 (0.026)*	3275.269 (0.000)*
Tertiary education participation	-0.006 (0.134)	1.787 (0.001)*
Expenditure on education	-6.941 (0.009)*	253.343 (0.239)
Employment in knowledge-intensive activities	1.994 (0.000)*	-75.243 (0.084)**
Early leavers from education	-0.214 (0.760)	54.028 (0.046)*
Share of world exports	-0.144 (0.849)	29.169 (0.006)*
Market integration in goods	-0.501 (0.000)*	-14.236 (0.251)
Market integration in services	1.483 (0.000)*	-17.773 (0.320)
E-government availability	-0.106 (0.123)	29.353 (0.001)*
Transposition of EU law	0.127 (0.008)*	-20.857 (0.000)*
Greenhouse gas emissions	-0.000 (0.212)	0.011 (0.000)*
R-squared	0.399	0.740
F test	11.12	50.58

Note: *indicates 5% significance, ** indicates 10% significance.

In the first equation, the dependent variable was Purchasing Power Parities, as a variable indicating growth. Factors positively affecting growth are the gas production, research and development, knowledge intensive employment, market integration of services and transposition of European Union law. Significant with a negative sign were: Expenditure on education and market integration of goods. The second equation with production of renewable energy as dependent variable has the following significant variables: oil production, energy dependence, resource and development, tertiary education participation, early leavers from education, transposition of European Law and greenhouse emissions. Negative signs were marked in gas production, coal and lignite production.

Overall, the simultaneous equation model (Table 3) does not confirm the resource curse hypothesis for Europe. Also, based on the first equation of the model, the production of renewable energy was not significant for growth, a fact which is also reported in other relevant literature (Menegaki, 2011, 2012). Elaborating further on the results from the second equation, we believe that the positive sign of crude oil can be attributed to its contribution to growth. High oil producing countries in Europe are industrialized countries. It is also those countries that emphasize and spend on renewable energy technologies development. The negative sign of gas and coal production is as expected by intuition. It is also logical that countries with a focus on renewable energy development are also countries that promote education. After all, with the absence of the latter, it would be impossible to achieve the former. The positive sign of greenhouse emissions was not expected but we believe that it is countries with high emissions that are interested more to develop renewable energies with the aim to reduce this magnitude in the long-run. Last, both models are significant and with adequate explanatory power. The movements of renewable energy, gas and crude oil are depicted in Figure 2.

Figure 2. Renewable energy, gas, oil and coal production in Europe from 2000-2009



Observing Figure 2, we encounter four patterns of renewable energy and fossil energy production. The first group of countries with renewable energy production from zero to a threshold of roughly 300,00 toes is also characterized by low to medium production of fossil fuels (gas, oil and coal) reaching up to the amount of 15,000 toes. The second group is characterized by the same low level renewable energy production but high gas and coal energy production (reaching up to 28,000 toes). The third group is from medium to high renewable energy production but with low to medium fossil resources energy production, while the fourth group of countries is characterized by medium to high renewable energy production and high coal production only.

5. Conclusion

Resource curse is the paradox of growth stagnation in countries rich with natural resources. The current paper is an empirical study of the curse for European countries and its novelty lies not only in that this kind of research is applied for Europe but mainly and foremost that it also introduces renewable energy resources in the context. The fact that renewable energies have not developed so far evenly or sufficiently in Europe begs the question of whether they have an effect on the degree of manifestation of the resource curse phenomenon. European Union consists of developed or highly developed countries; therefore the phenomenon was not so intense.

The paper uses a single fixed effects model and a simultaneous two equation model with variables such as primary production of crude oil, natural gas, coal and lignite, resource productivity, energy dependence, investment, research and development expenditure, tertiary education participation, expenditure on education, employment in knowledge intensive activities, early leavers from education, share of world exports, market integration of goods and market integration of services, e-government availability, transposition of European Law and greenhouse emissions.

In the first model, the resource curse hypothesis is confirmed only for crude oil and the resource productivity variable. Production of renewable energy is positive but with a very small coefficient. In the second model there is no evidence neither for the resource curse nor for the renewable energies blessing. In the second equation of the second model, we observe that renewable energy sources increase in the same direction as crude oil production and at the opposite direction of gas, coal and lignite production. Also, renewable energies increase together with energy dependence, research and development expenditure, tertiary education participation, the share of world exports, e-government availability, transposition of European Union law and greenhouse emissions. The simultaneous significance of crude oil production, with greenhouse emissions in this equation might be due to the fact that crude oil producers in Europe are also rich, industrialized countries with a focus to develop renewable energies.

Renewable energy sources will eventually substitute or ideally crowd out the natural resources in the long-run. Although our data did not permit the validation of a Dutch effect for Europe, since we would additionally need data about price levels, investigating the role of renewable energy sources will contribute to soothing, if not canceling out, the resource curse, because rent seeking behavior is less probable in diffuse natural resources. Emphasis must be laid on the elite groups that might hinder renewable resources development to protect their established status-quo. Apt fiscal policy that will lead to a stable growing of renewable energies will help Europe to grow in a 'sterilized manner' so that not to fire Dutch effects. Humanity is entitled to dividends from renewable energy and policy should work towards this directions.

References

Alesina, A., Baqir, R., Easterly, W. (1998). *Redistributive public employment*. Journal of Urban Economics, 48, 219–241.

Andersen, J.J., Aslaksen, S. (2008). *Constitutions and the resource curse*. Journal of Development Economics, 87(2), 227-246.

Auty, R.M. (2001). *The political economy of resource-driven growth*. European Economic Review, 45(4–6), 839-846.

Borenstein, S. (2012). *The private and public economics of renewable electricity generation*. Journal of Economic Perspectives 26(1): 67-92.

Boschini, A.D., Pettersson, J., Roine, J. (2007). *Resource curse or not: a question of appropriability*. Scandinavian Journal of Economics 109 (3), 593–617.

Breusch, T., Pagan, A. (1980). *The LM Test and its Applications to model specification in Econometrics*. Review of Economic Studies 47: 239-254.

European Commission, (2001). Directive 2001/77/EC of the European Parliament and of the Council on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market, Official Journal of the European Communities, L 283/33-40.

European Commission, (2002). Directive 2002/91/EC of the European Parliament and of the Council on the Energy Performance of Buildings, Official Journal of the European Communities, L 001/65-71.

European Commission, (2003). Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels and other renewable fuels for transport, Official Journal of the European Communities, L 123/42-46.

European Commission, (2009). Directive 2009/28/EC of the European parliament and of the council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union, L 140/16-62.

Greene, W.H. (2003). *Econometric Analysis*, 5th ed., Upper Saddle River, New Jersey, Prentice Hall

Greene, W.H. (2007). Limdep, Version 9.0., Econometric modeling Guide, Vol.2.

Gylfason, T., (2008). *Development and Growth in Mineral-Rich Countries*, CEPR Discussion Paper no. 7031. [In: Kolstad, I., and Wiig, A. (2009). It's the rents, stupid! The political economy of the resource curse. Energy Policy, 37(12), 5317-5325].

Hausman, J. (1978). *Specification tests in econometrics*, Econometrica 46: 1251-1271.

James, A., Aadland, D. (2011). The *curse of natural resources: An empirical investigation of U.S. counties*. Resource and Energy Economics, 33(2), 440-453.

Judge, G., Griffiths, W., Hill, C., Lee, T. (1985). *The theory and Practice of Econometrics*, New York: John Wiley and Sons.

Kolstad, I., Wiig, A. (2009). *It's the rents, stupid! The political economy of the resource curse*. Energy Policy, 37(12), 5317-5325.

Leamer, E.E., Maul, H., Rodriquez, S., Schott, P.K. (1999). *Does natural resource abundance increase Latin American income inequality?* Journal of Development Economics 59, 3–42.

Mehlum, H., Moene, K.O., Torvik, R. (2006). *Institutions and the resource curse*. The Economic Journal 116, 1–20.

Menegaki, A. (2011). *Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis*, Energy Economics, 33, 257-263.

Menegaki, A.N. (2012). *A social marketing mix for renewable energy in Europe based on consumer stated preference surveys*. Renewable Energy, 39(1), 30-39.

Mikesell, R.F. (1997). *Explaining the resource curse, with special reference to mineral-exporting countries*. Resources Policy, 23(4), 191-199.

Papyrakis, E., Gerlagh, R. (2004). *The resource curse hypothesis and its transmission channels*. Journal of Comparative Economics, 32(1), 181-193.

Robinson, J.A., Torvik, R., Verdier, T. (2006). *Political foundations of the resource curse*. Journal of Development Economics, 79(2), 447-468.

Sachs, J.D., Warner, A.M. (2001). *The curse of natural resources*. European Economic Review, 45(4–6), 827-838.

Stijns, J.P. (2006). *Natural resource abundance and human capital accumulation*. World Development, 34(6), 1060-1083.

van der Ploeg, F., and Poelhekke, S. (2010). *The pungent smell of "red herrings": Subsoil assets, rents, volatility and the resource curse*. Journal of Environmental Economics and Management, 60(1), 44-55.

Williams, A. (2011*). Shining a Light on the Resource Curse: An Empirical Analysis of the Relationship between Natural Resources, Transparency, and Economic Growth*. World Development, 39(4), 490-505.

A1. COUNTRIES

The 31 countries in the analysis are: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxemburg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, UK, Iceland, Norway, Switzerland, and Croatia.

A2. DATA APPENDIX

The variables used in the econometric analysis are listed below. They were downloaded from the following hyperlinks: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode and http://appsso.eurostat.ec.europa.eu/nui/print.do?print=true

1) **TRA:** Transposition of EU law: The indicator is about the degree to which national measures implementing directives (code: tsdgo220).

2) **IGO-IGS:** Market integration-Trade integration of goods and services as a percentage of GDP. Average of inputs and exports of the items goods and services of the balance of payments divided by GDP. If the index increases over time it means that the country is becoming more integrated within the international economy (code: tsier120).

3) **SWE:** It shows developments in shares of exports of goods and services of EU member states in the total world exports. Data on the values of exports and services are compiled as part of the balance of payments of each country. To capture the structural losses in competitiveness that can accumulate over longer time periods, the indicator is calculated comparing year Y with year Y-5. The indicator is based on the balance of payments data reported by the 27 EU member states (code: tipsex10).

4) **EAR:** Early leavers from education and training: It refers to persons aged 18 to 24 not having received any education or training four weeks preceding the survey (numerator). The denominator consists of the total population of the same age group, excluding no answers to the questions "highest level of education or training attained" and "participation to education and training". Both the numerators and the denominators come from the European Union labour force survey (code: tsisc060).

5) **KNO:** Annual data on employment in knowledge-intensive activities. Total knowledge-intensive activities as percentage of total employment (code: htec_kia-emp).

6) **EED:** Expenditure on education as percentage of GDP (code: educ_figdp).

7) **TERT:** Tertiary education participation (code: educ_itertp).

8) **RD:** Research and Development expenditure as percentage of GDP. It comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including

knowledge of man, culture and society and the use of this stock of knowledge to devise new applications. The variable includes all expenditures for R&D performed within the business enterprise sector percentage of GDP (R&D intensity) (code: tsc00001).

9) **DEP:** Energy Dependence as percentage of net imports in gross inland consumption. It shows the extent to which an economy relies upon imports in order to meet its energy needs. The indicator is calculated as net imports divided by the sum of gross energy consumption plus bunkers (code: tgigs360).

10) **COAL:** Primary production of coal and lignite (in 1000 toes). It consists of quantities of fuels extracted or produced, calculated after any operation for removal of inert matter. In general, primary production includes the quantities consumed by the producer in the production process (e.g. for heating or operation of equipment and auxiliaries) as well as supplies to other on-site producers of energy for transformation or other uses (code: ten00077).

11) **GAS:** Primary production of natural gas (in 1000 toes). Dry marketable production, measured after purification and extraction of natural gas liquids and sulphur is considered as primary production. It does not include quantities re-injected, extraction losses, or quantities vented and flared. It includes quantities used within the natural gas industry, in gas extraction, pipeline systems and processing plants (code: ten00079).

12) **PRE:** Primary production of renewable energy: biomass, geothermal energy, wind and social energy (code: ten00081).

13) **RPR:** Resource productivity. It is GDP divided by domestic material consumption (DMC). DMC measures the total amount of materials directly used by an economy. It is defined as the annual quantity of raw materials extracted from the domestic territory of the focal economy, plus all physical imports minus all physical exports. It is important to note that the term consumption as used in DMC denotes apparent consumption and not final consumption. DMC does not include upstream flows related to imports and exports of raw materials and products originating outside the focal economy. When examining resource productivity trends over time in a single geographical region, the GDP that should be used is in units of euros in chain-linked volumes to the reference year 2000 at 2000 exchange rates (code: tsdpc100).

14) **OIL:** Primary production of crude oil. Primary production within national boundaries including offshore production is covered. Production should only include marketable production, excluding volumes returned to formation. Such production should include all crude oil, natural gas liquids, condensates and oik from shale and tar sands etc (code: ten00078).

15) **INV:** Total investment as percentage of GDP. This indicator shows the investment for the total economy, government, business as well as household sectors. The indicator gives the share of GDP that is used for gross investment. It is defined as gross fixed capital formation (GFCF), expressed as a percentage of GDP for the government, business and household sectors. GFCF consists of resident producers' acquisitions, less disposals of fixed assets plus certain additions to the value of non-produced assets realized by productive activity, such as improvements to land. Fixed assets comprise, e.g. dwellings, other buildings and structures, machinery and equipment, but also intangible assets such as computer software (code: tsdec210).

16) **PPS:** GDP per capita in PPS. The volume index of GDP per capita in PPS is expressed in relation to the European Union (EU-27) average set to equal 100. If the index of a country is higher than 100, this country's level of GDP per head is higher than the EU average and vice-versa. PPS is a common currency that eliminates the differences in price levels between countries allowing meaningful volume comparisons of GDP between countries (code: tec00114).

17) **GRE:** Greenhouse gas emissions in thousand of tonnes (CO_2 equivalent), (code: env_air_gge).